Cosmic-ray background in PHENIX detector

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High-energy photons are important probes in the field of nuclear physics. They provide early-stage information on nuclear collisions. At PHENIX[1)], photons are detected by the electromagnetic calorimeters (EMCals). One problem is a cosmic-ray event can be identified as a direct photon event. Fig. 1 shows two examples of cluster shapes in EMCals made by cosmic-rays. The clusters with the shape shown in Fig. 1(a) can be easily eliminated; however, those with the shape shown in fig.1(b) are retained. Competition exists between the rates of the real signal and the cosmic event. Since the signal rate is considerably lesser in $p+p$ collisions, the contribution of cosmic-rays is a more serious problem in $p+p$ collisions than in $Au+Au$ collisions.

In 2007, control data were obtained when there was no activity in the accelerator for a total period of about 20,000 s. Fig. 2 shows the energy spectra of this data set. The EMCal miscalculates the energy deposit of cosmic-ray hits because it is calibrated for photons coming from the collision.

Fig. 3 shows the energy spectra for a total of 6.5×10^{10} events triggered by $p+p$ (at $\sqrt{s} = 200$ GeV) collisions. The thick line represents all the clusters, the dashed line represents the clusters with $|ToF| < 5$ ns, and the thin line represents the clusters with $|ToF| > 5$ ns. Since the beam crossing interval is about 100 ns, a reduction in background by a factor of 10 is expected in the case of $|ToF| < 5$ ns. The background is dominant in the high-energy region.

Two plots (Figs. 2 and 3) are compared by multiplying a factor calculated using the data-accumulation period and the probability of having collisions in coincidence. The factor is obtained using the following formula:

$$T_1 \cdot \frac{1}{T_0} \cdot \frac{R}{R_{cross}} = \frac{6.5 \times 10^{10}}{R} \cdot \frac{1}{20300} \cdot \frac{R}{10 \times 10^6} = 0.32,$$

where T_0 and T_1 are data-accumulation periods, and R (R_{cross}) is the rate of collisions (accelerator crossings). With this factor, the rate of cosmic-ray (Fig. 2) and the background rate in the collision data (Fig. 3) are consistent.

In this report, the background component in $p+p$ collisions at $\sqrt{s} = 200$ GeV identified using ToF information is explained by cosmic-ray contribution. At a high center-of-mass energy (e.g., 500 GeV), we need to handle rarer signals. The ToF information is essential to reduce cosmic-ray background.

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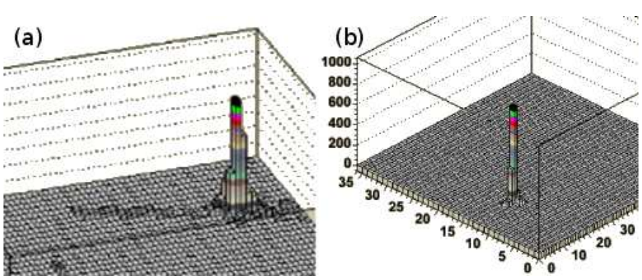

Fig. 1. Cosmic ray cluster examples. Each square corresponds to a EMCal tower. The hight is proportional to the pulse hight.

References

1) K. Adcox et al.: Nucl. Inst. Meth. A **499**, 469 (2003).

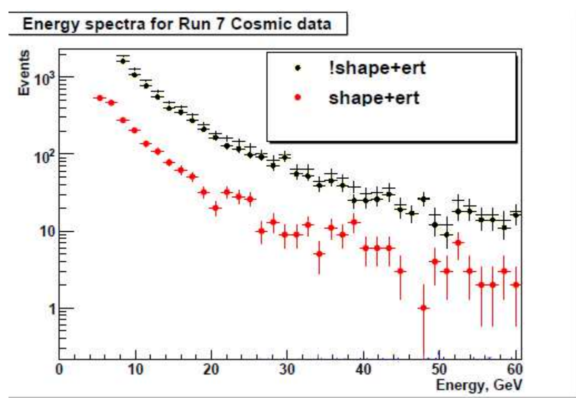

Fig. 2. Energy distribution of cosmic-ray data obtained over 20,000 s. The clusters (the top histogram) are divided into two groups by the shape cut. The bottom histogram shows good shape clusters.

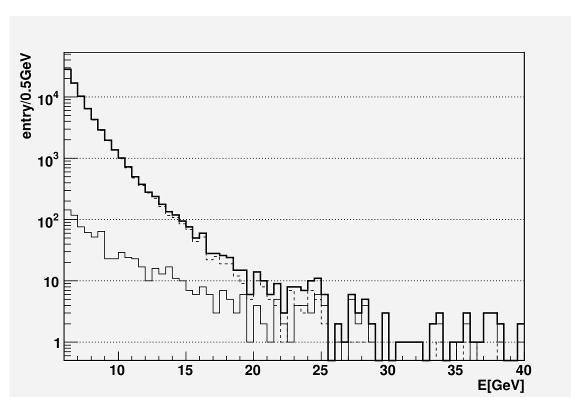

Fig. 3. Spectra of photon-like clusters with 6.5×10^{10} minimum bias collision triggered data (RHIC Run5pp). The thin-line histogram is for clusters out of collision timing ($|ToF| > 5$ ns).